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INT CL^5 **F02D 43/00 , F02P 5/04**
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(54) Method of and equipment for setting the torque of an internal combustion engine

(57) A method of setting the torque of an internal combustion engine makes use of induction air mass flow and ignition angle. The actual torque is normalised for a target ignition angle (ZW_SOLL), whereby the ignition-angle-dependent component in the actual torque is not taken into consideration in the torque thus ascertained. The normalised torque value ($\hat{M}$_ZWORM) is compared with a target torque value (M_SOLL) in order to obtain a torque deviation (ΔM), from which an integration value (M_INT) is formed and employed to modify the target torque (M_SOLL) to obtain an effective torque value (M_EFF), which in turn influences the determination of a control angle (α) for the engine throttle flap. The torque deviation (ΔM) is also used to modify an ignition angle deviation (ΔZW), which in turn modifies a target ignition angle (ZW_SOLL) to provide an actual ignition angle (ZW_AKT).

FIG. 1

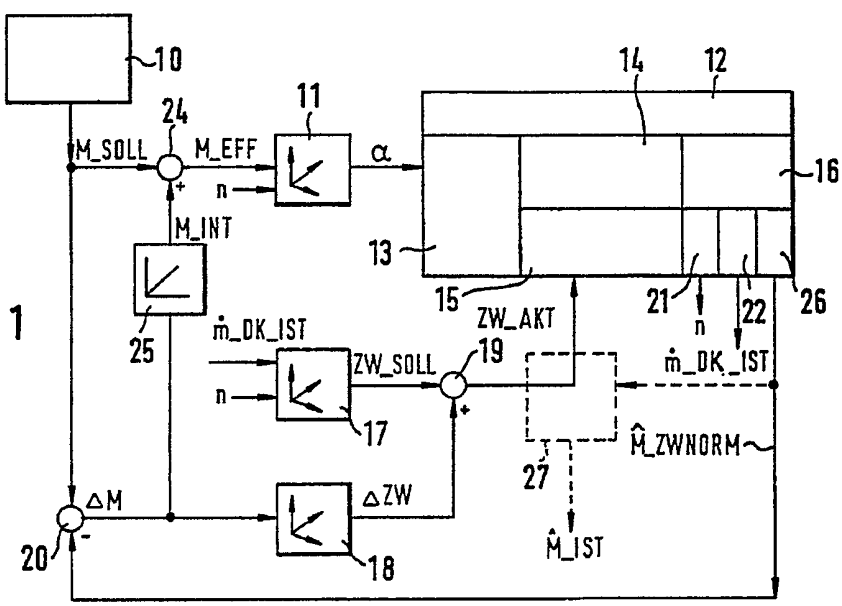

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FIG. 1

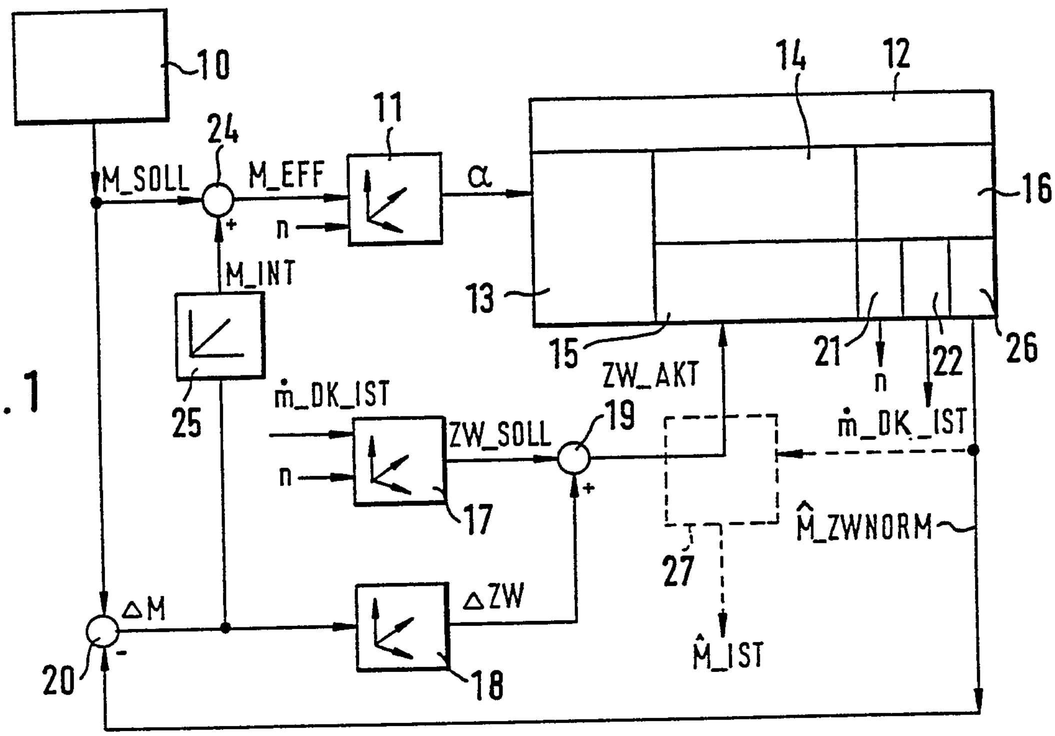
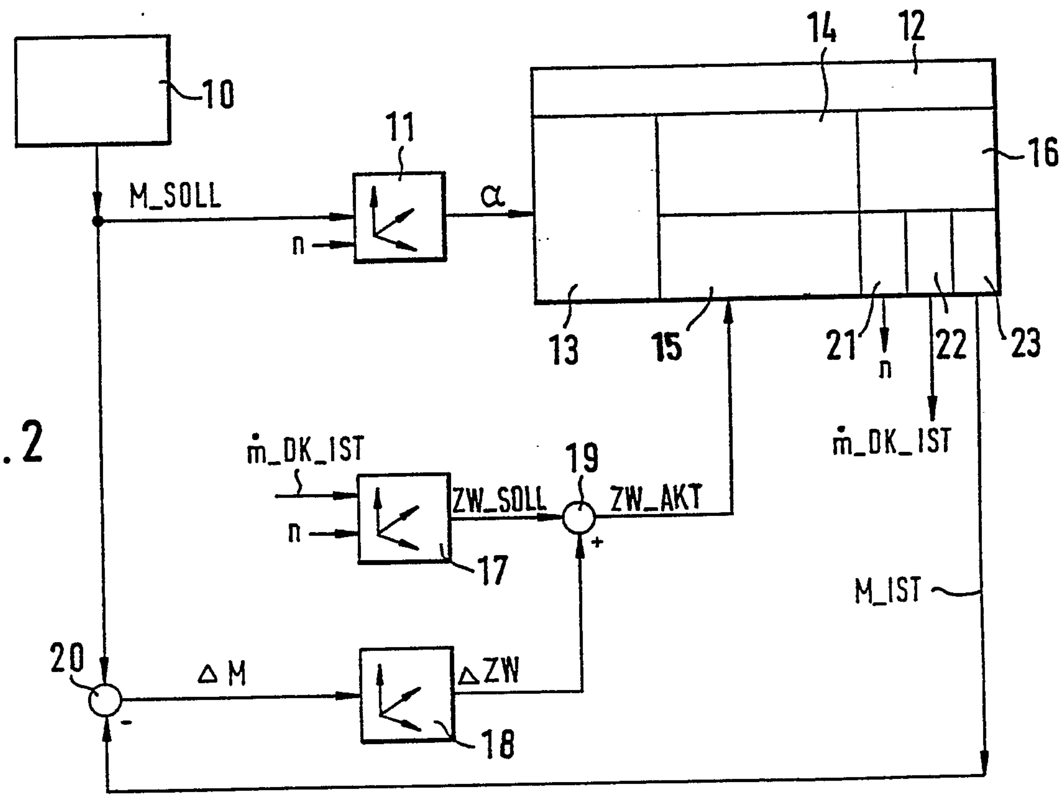

10
M_SOLL
24
M_EFF
11
α
n
M_INT
25
14
12
16
13
15
21
n
22
26
ZW_AKT
ṁ_DK_IST
ZW_SOLL
19
n
17
ṁ_DK_IST
M̂_ZWNORM
27
ΔM
ΔZW
20
18
M̂_IST

FIG. 2


10
M_SOLL
11
α
n
14
12
16
13
15
21
n
22
23
ṁ_DK_IST
ṁ_DK_IST
ZW_SOLL
19
ZW_AKT
n
17
M_IST
20
ΔM
ΔZW
18

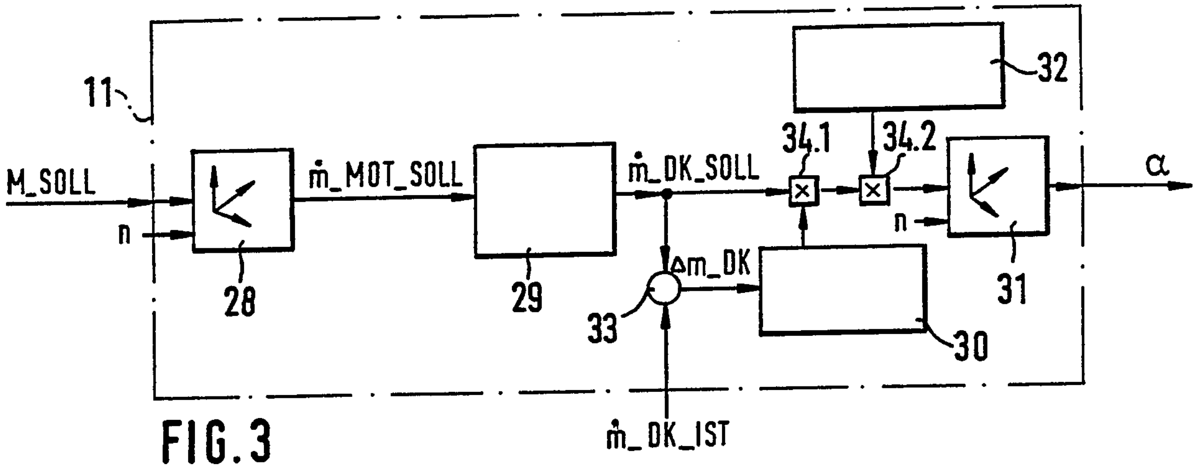


FIG. 3

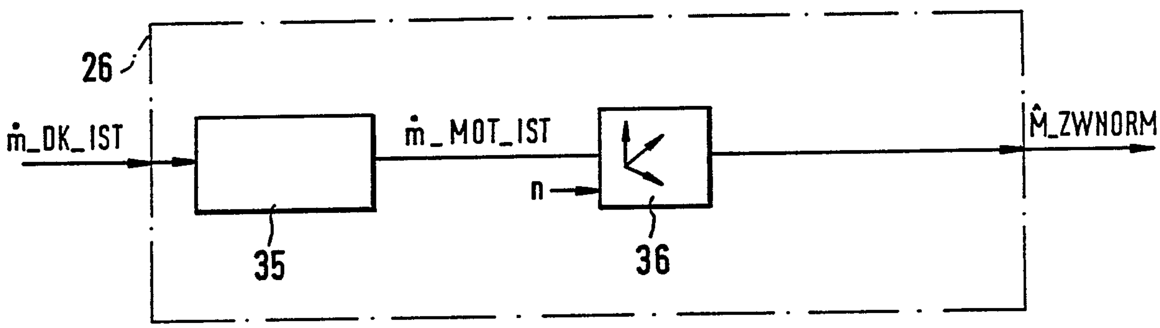


FIG. 4

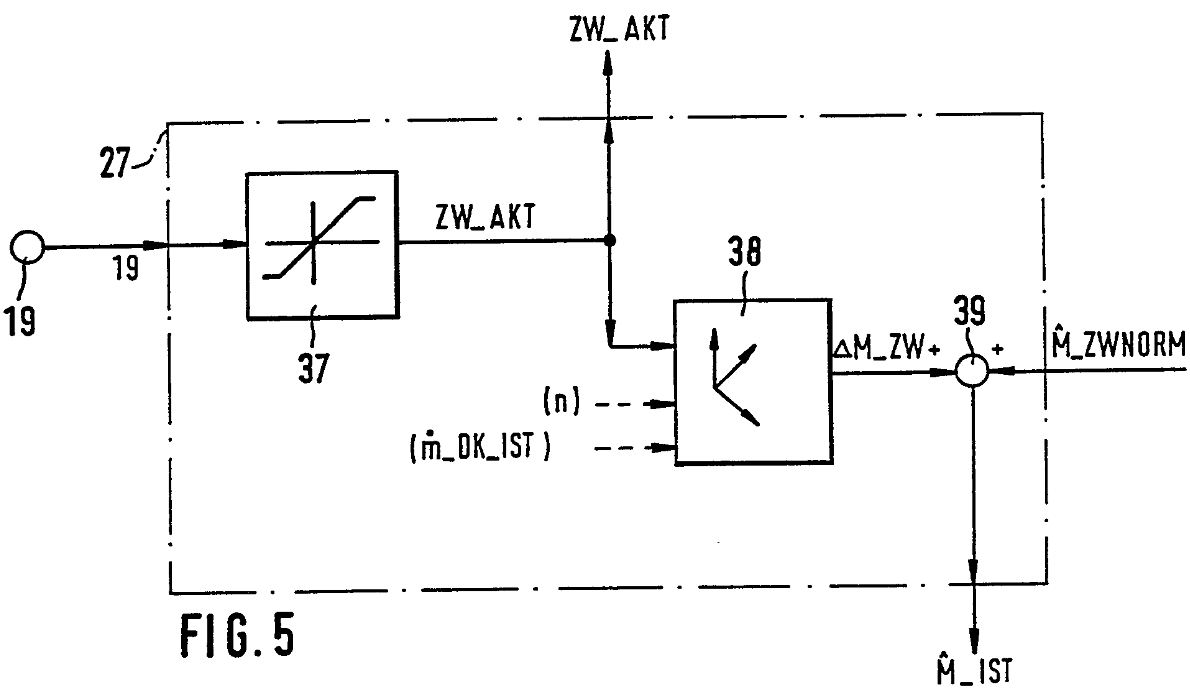


FIG. 5

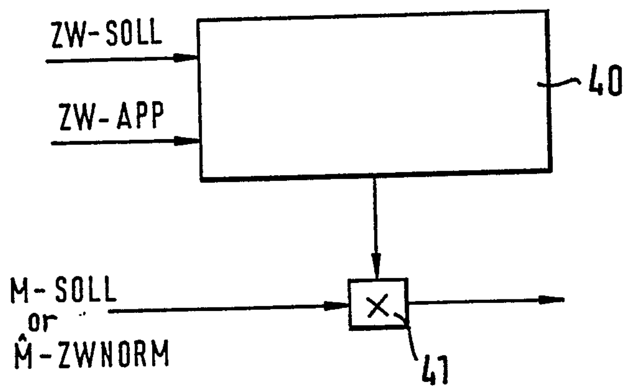


FIG.6

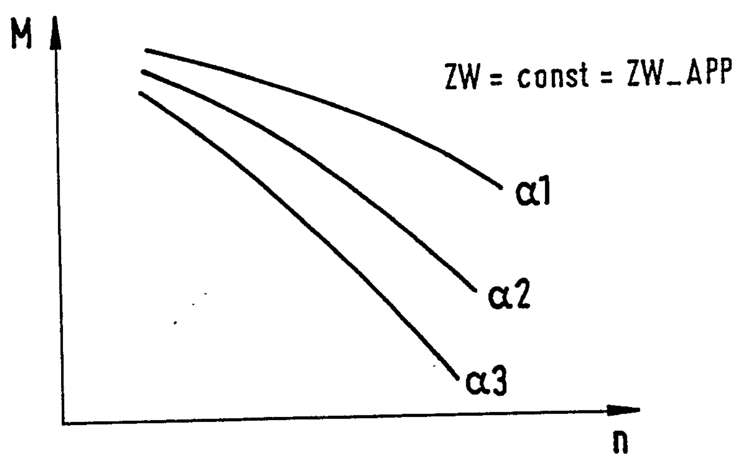


FIG.7

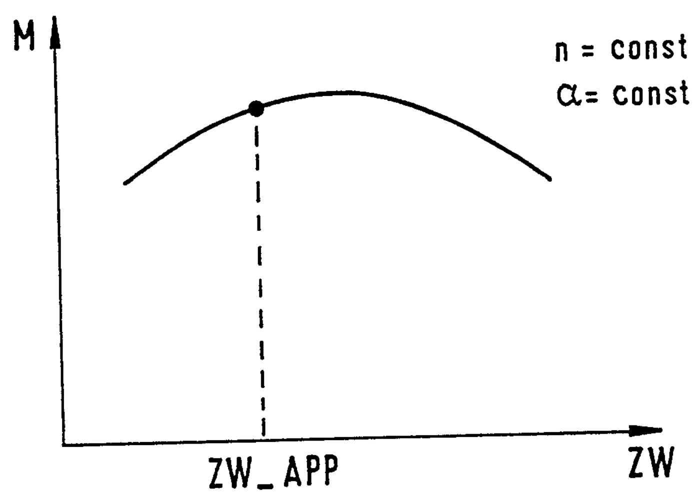


FIG.8

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METHOD OF AND EQUIPMENT FOR SETTING THE TORQUE OF AN INTERNAL COMBUSTION ENGINE

The present invention relates to a method of and equipment for setting the torque of an internal combustion engine, i.e. an Otto engine.

Before known methods and equipment of this kind are discussed, different terms will be explained by reference to the Figs. 7 and 8 of the accompanying drawings. Fig. 7 is a diagram showing the respective relationship between engine rotational speed n and engine torque M for three different throttle flap angles $\alpha 1 > \alpha 2 > \alpha 3$. The curves all apply to the same constant ignition angle ZW. As is known, the torque decreases with increasing rotational speed and reduces the throttle flap angle (reduced air mass flow). Fig. 8 is a diagram showing the dependence of the torque M on the ignition angle ZW at constant rotational speed and constant throttle flap. It can be seen that a maximum torque is achieved for a certain ignition angle.

The constant ignition angle at which the measurements according to Fig. 7 took place is denoted by ZW_APP in the Figs. 7 and 8, wherein "APP" indicates that a magnitude is concerned which is kept constant for one application. An application is an operation in which the change in the value of a particular magnitude of an engine, for example torque, is measured in dependence on the change of the value of another magnitude, for example rotational speed, with as many parameters as possible being kept constant, for example ignition angle. It is evident from Figs. 7 and 8 when considered together that the curves of Fig. 7 were recorded for an ignition angle which does not lead to maximum torque at the rotational speed and throttle flap angle selected for Fig. 8. A curve such as that of Fig. 8 enables, starting out from a torque as evident from Fig. 7, the ascertaining of the torque that would be present for an ignition angle different from that for which the curves according to Fig. 7 were applied. In the following description it is mentioned that a torque is normalised for a target ignition angle. This means that, with the aid of a torque-angle relationship according to Fig . 8, there is ascertained that torque value which would be present for the target ignition angle when the torque is known for an actual ignition angle.

In the following, induction air regulating means, i.e. air-admetering equipment, is mentioned. A throttle flap is mostly used as air-admetering equipment in present day engines. In addition to the throttle flap, a bypass duct with an adjustable air throughput can be present, which bypass equipment is used in addition to the throttle flap for regulating the air feed. Moreover, it is also possible to set the air mass flow inducted into the combustion chambers by variable inlet valve control times, for example as described in DE-A-39 40 752.

A method and equipment for presetting the torque of an internal combustion engine of a vehicle are described in the not previously published German patent application DE-P 41 11 023. This method is based inter alia on the consideration that the vehicle driver predetermines a certain drive torque at the wheels of the vehicle by accelerator setting. This desired drive torque requires a certain engine torque, but this, however, depends not only on the desired drive torque, but also on, for example, additional torque components for the driving of accessories, such as an air conditioning installation or a generator for lighting, and on how much frictional energy is to be overcome, which magnitude depends particularly on engine temperature. The engine output torque is therefore not determined solely in dependence on accelerator setting, which in the end result only represents a desired wheel-driving torque, but is determined in dependence on many magnitudes.

In the method and equipment of the above-mentioned German patent application, the air mass flow (in an Otto engine) or the fuel flow (in a diesel engine) is controlled in dependence on the desired engine torque. No information is evaluated, which would indicate whether the desired target torque is in fact achieved. It is therefore readily possible that the actual torque differs from the target torque.

There thus remains a need for a method and equipment which may enable actual torque to agree as accurately as possible with target torque.

According to a first aspect of the present invention there is provided a method of setting the torque of an internal combustion engine equipped with induction air regulating means, comprising the steps of predetermining a target torque value, ascertaining a target ignition angle predetermined for the actual engine operating conditions, determining the value of the actual torque normalised for the target ignition angle, determining the value of the deviation between the target torque value and normalised actual torque value, integrating the torque deviation value and correcting the target torque value by the integration value to obtain an effective torque value, controlling the regulating means by a control value dependent on the effective torque value, determining an ignition angle deviation value in dependence on the torque deviation value and so modifying the target ignition angle by the ignition angle deviation value as to provide an actual ignition angle influencing torque in a direction towards agreement of the actual torque value with the target torque value.

According to a second aspect of the present invention there is provided equipment for setting the torque of an internal combustion engine equipped with air induction regulating means, comprising means for predetermining a target torque, means for ascertaining a target ignition angle predetermined for the actual engine operating conditions, means for determining the value of the actual torque normalised for the target ignition angle, means for determining the value of the torque deviation between the target torque value and normalised actual torque value, means for integrating the torque deviation value and correcting the target torque value by the integration value to obtain an effective torque value, means for controlling the regulating means by a control value dependent on the effective torque value, means for determining an ignition angle deviation value in dependence on the torque deviation value and means for so modifying the target ignition angle by the ignition angle deviation value as to provide an actual ignition angle influencing torque in a direction towards agreement of the actual torque value with the target torque value.

A method exemplifying and equipment embodying the invention so operate that they set the actual torque not only through change in the air feed, but also through variation of the ignition angle with the use of a feedback. However, it is not the actual torque value that is fed back, but the value of actual torque normalised for the target ignition angle, the target ignition angle being that ignition angle which is applied as the optimum (according to power or consumption) ignition angle for the actual operating conditions of the engine. The deviation between the target torque and the normalised actual torque is integrated and the target torque is modified by the integration value in order to obtain an effective torque which serves for the determination of a control value by which the induction air regulating means, i.e. air admetering device, is driven.

This particular choice of the feedback and the integration of the torque deviation have the consequence that a deviation, which is present after making a change in the target torque, of the actual ignition angle from the applied ignition angle is gradually reduced to zero so that the target torque is finally obtained at the applied, thus at the optimum, ignition angle solely with corresponding setting of the air-admetering device. The advantage of this procedure is that large changes in the torque can in all cases be set by way of the air quantity, whilst a very rapid fine adaptation is effected with the ignition angle. After such fine adaptation through the ignition angle, this adaptation is also gradually undertaken by way of the air feed, whilst the fine adaptation through the ignition angle is reversed so that the optimum applied target ignition angle is again present at the end.

The feedback value can be ascertained in different ways. One possibility consists of measuring the actual torque of the engine by a sensor, ascertaining the actual ignition angle at the same time, and proceeding from these values, determining the torque which would be present for the target ignition angle. Another possibility, without use of a torque sensor, consists of ascertaining the air mass flow inducted into the combustion chambers and, from this air mass flow and with the aid of a relationship - applied for the target ignition angle - to the engine torque, ascertaining the latter as feedback value.

Examples of the method and embodiments of the equipment of the present invention will now be explained by reference to the accompanying drawings, in which:

Fig. 1 is a block diagram of equipment embodying the invention;

Fig. 2 is a block diagram of a preliminary stage of such equipment;

Fig. 3 is a block diagram of means for determining a driving value for an air admetering device in such equipment;

Fig. 4 is a block diagram of means for ascertaining engine torque normalised for a target ignition angle in such equipment;

Fig. 5 is a block diagram of means for the fixing of an actual ignition angle in such equipment;

Fig. 6 is a block diagram of means for determining a correction factor for a torque value in such equipment;

Fig. 7 is, as already noted, a diagram showing the dependence of torque on engine speed; and

Fig. 8 is, again as already noted, a diagram showing the dependence of torque on ignition angle.

Referring now to the drawings, Figs. 1 to 6 are diagrams which can be regarded as illustrative of examples of the method of the invention as well as embodiments of the equipment of the invention. In the following, the term "system" is used as collective term for both method and equipment.

Fig. 2 is a diagram of a preliminary stage of such a system. In terms of equipment, the system comprises a device 10 for the setting of a target torque M_SOLL and a throttle flap angle-determining device 11 for throttle flap angle α of a throttle flap 13 of an engine 12 with combustion chambers 14, an ignition angle-setting device 15, a data-measuring device 16, a characteristic values field 17 for the issue of a target ignition angle ZW_SOLL, a characteristic values field 18 for the issue of an ignition angle deviation ΔZW, an ignition angle summation device 19 and a torque subtraction device 20. The data-measuring device 16 has three components, namely a rotational speed sensor 21 for measuring engine rotational speed n, an air mass flow sensor 22 for measuring air mass flow $\dot{m}$_DK_IST inducted by way of the throttle flap and a torque sensor 23 for measuring the total torque M_IST delivered by the engine, as it depends on the rotational speed, the combustion chamber filling and the ignition angle.

The function of the system of Fig. 2 is described in the following. It will be assumed that the device 10 for presetting of the target torque over a certain time span issues a target torque which is significantly increased by comparison with the previously valid target torque. A throttle flap angle α, as was applied previously for a certain ignition angle, is then read out from the device 11 in dependence on the actual rotational speed n. Since it has been assumed that the torque is to be increased, the throttle flap angle read out is greater than that previously set. The throttle flap 13 is not set with this value. The air mass flow $\dot{m}$_DK_IST is then inducted by the engine 12, as measured by the associated sensor 22. As a consequence of combustion of the inducted fuel-air mixture in the combustion chambers 14, an engine torque M_IST is provided and is measured by the associated sensor 23. It will now be assumed that the increase in target torque over time is greater than can be realised by sudden increase in the opening of the throttle flap 13. The actual torque value M_IST then lies below the target torque value M_SOLL, whereby a torque deviation value ΔM, which is formed in the device 20, is positive. An associated ignition angle deviation ΔZW is read out from the field 18. At the same time, a target ignition angle ZW_SOLL is read out from the field 17 in dependence on the actual engine speed n and the actual inducted air mass flow $\dot{m}$_DK_IST, to which ignition angle the deviation ΔZW is added in the summation device 19 to obtain an ignition angle ZW_AKT which is actually to be set. The sign of the ignition angle deviation ΔZW is in that case so selected that a greater torque arises for the ignition angle ZW_AKT and for the ignition angle ZW_SOLL. If the applied ignition angle ZW_APP were to correspond to the target ignition angle ZW_SOLL in Fig. 8, ΔZW would have to be positive in order to cause an increase in torque.

It is evident from the preceding that, with the aid of a change in ignition angle, such a change in torque can be caused rapidly as would not be possible through a change in the air mass flow. However, a problem with the system according to Fig. 2 is that the deviation of the actual ignition angle from the target ignition angle cannot be reversed if the new target torque value is maintained for some time. This disadvantage is overcome by the system according to the invention according to Figure 1.

The system according to Fig. 1 differs from that of Fig. 2 by two additional devices and a modified device. In particular, a torque-correcting device 24 and an integrator 25 are present, and the device for detection of the torque is modified in the sense of replacing the torque sensor 23 by an ascertaining device 26 for the ascertaining of an estimated torque $\hat{M}$_ZWNORM normalised for ignition angle. The function of the system of Fig. 1 is the following.

An increase in torque at a certain instant will again be assumed. The integrating device 25 would at this instant issue the integration value M_INT of zero. This integration value is added in the torque-correcting device 24 to the target torque M_SOLL in order to form the effective torque M_EFF. The throttle flap angle-determining device 11 is now driven by this value instead of directly by the target torque M_SOLL as in the case of the system according to Fig. 2. The following sequences agree with those explained by reference to Fig. 2 and the engine again delivers the torque M_IST. It is not the torque M_IST that is ascertained, however, but the torque $\hat{M}$_ZWNORM normalised for ignition angle, in a mode and manner as described further below by reference to Fig. 4. This is evaluated in the torque-subtracting device equipment 20 instead of the actual torque M_IST. It will be assumed that the torque normalised for ignition angle is smaller than the target torque, whereby a positive torque deviation ΔM is again obtained. This is processed with respect to ignition angle by the devices 17, 18 and 19, as described above by reference to Fig. 2. In addition, processing in a device 27 for ignition angle limitation can take place, as explained further below by reference to Fig. 5.

The torque deviation ΔM is used not only for change in ignition angle, but also for setting of the torque. The deviation is integrated in the integrating device 25 and the integration value M_INT is, as already indicated, added in the torque-correcting device 24 to the target torque M_SOLL. When the torque deviation ΔM is temporarily not equal to zero, for example because of a dynamic transient behaviour, or when it differs from zero over a longer time due to an inaccuracy in the throttle flap angle-determining device 11, the effective torque M_EFF is increased so far relative to the target torque M_SOLL that the torque $\hat{M}$_ZWNORM normalised for ignition angle finally agrees with the target torque M_SOLL, whereby the torque deviation ΔM ultimately becomes zero. The integration value M_INT is then not changed further. At the same time, the ignition angle ΔZW assumes the value of zero. Consequently, the actual ignition angle ZW_AKT agrees with the target ignition angle ZW_SOLL, which is so applied that it leads to optiumum engine behaviour selectably according to power or fuel consumption). The deviation from the optimum ignition angle is thus only temporary in order to set the new desired target torque as rapidly as possible. The change in torque undertaken rapidly with the aid of the ignition angle adjustment is then taken over gradually with the aid of the integration value M_INT and thereby the air mass flow setting.

It should be noted that not just a characteristic representing the relationship between the torque deviation ΔM and the ignition angle deviation ΔZW two-dimensionally can be stored in the ignition angle deviation characteristic field 18. The stored characteristic could have a higher-dimensionality, in which, for example, engine speed n and/or the measured air mass flow $\dot{m}$_DK_IST are taken into consideration.

An example for a very accurate setting of the throttle flap angle α in dependence on the target torque M_SOLL is now described by reference to Fig. 3. According to Fig. 3, the throttle flap angle-determining device 11 comprises a mass flow characteristic values field 28, an inverse filling model device 29, an air mass flow regulator 30, a throttle flap angle characteristic values field 31, a temperature-compensating device 32, a mass flow subtracting device 33 and first and second multiplying devices 34.1 and 34.2, respectively. The field 28 receives the values for target torque M_SOLL and engine rotational speed n and in dependence on these values supplies a target air mass flow $\dot{m}$_MOT_SOLL, which is applied for a certain ignition angle ZW_APP and is as to be inducted by the combustion chambers, in order to achieve the desired target torque at the actual rotational speed when the application ignition angle is present. In fact the air mass flow flowing through the throttle flap in the case of dynamic processes differs from the flow to be inducted into the chambers. The dynamic dependence of the flow inducted into the chambers on the flow flowing through the throttle flap is reproduced by a so-called filling model. Such filling models are well known. In this connection, for example, reference may be made to the article by C.F. Aquino entitled "Transient A/F Control Characteristics of the 5 Liter Central Fuel Injection Engine", in SAE papers 810494, 1981, pages 1 to 15. In the present case, it is the converse relationship that matters, for which reason the model device 29 operates according to an inverse filling model. It then issues the target air mass flow $\dot{m}$_DK_SOLL, which must flow through the throttle flap in order to obtain the target air mass flow ṁ_MOT_SOLL to be inducted by the combustion chambers. The target value ṁ_DK_SOLL is then corrected in the two multiplying devices 34.1 and 34.2, which is described further below, and the corrected value, together with the actual value of the engine rotational speed n, drives the throttle flap angle field 31, which thereupon issues the throttle flap angle α, which is to cause an air mass flow at which the target torque M_SOLL sets in.

The corrections undertaken in the multiplying devices 34.1 and 34.2 are merely fine corrections which can be omitted without any influence on the basic functions of the system. The temperature-compensating device 32 takes into consideration that, for example, if the different characteristic values fields are applied at, for example, 20°C, but the actual temperature is higher, the throttle flap must be opened further in order to achieve the same air mass flow at this higher temperature than for the application temperature of 20°C. Thus, with increasing temperature it will issue a correction factor rising over the value 1, by which the target air mass flow is multiplied in the multiplying device 34.2 is multiplied. The air mass regulator 30, the air mass flow subtraction device 23 and the first multiplying device 34.1, thereagainst, take into account density changes of the air which are caused not by temperature, but by, for example, changes in height or weather. For this purpose, a comparison between the actual air mass flow and the target air mass flow is undertaken in the mass flow subtraction device. The associated air mass flow deviation $\Delta\dot{m}$_DK = $\dot{m}$_DK_SOLL - $\dot{m}$_DK_IST is passed onto the air mass regulator 30, which integrates the deviation, for example starting from the value of unity. The integration value is passed to the first multiplying device 34.1 as a factor for the multiplication with the target air mass flow. If the air mass regulator 30 integrates starting from the value of zero, an adding device is used for correction instead of a multiplying device. The air mass regulator 30 can have, apart from an integral component, a proportional component and/or a differential component. The integration value can be used as information concerning air density in still other devices of control equipment.

Figure 4 illustrates an example of the device 26 for ascertaining the torque $\hat{M}$_ZWNORM normalised for ignition angle. This device receives the signal $\dot{m}$_DK_IST from the air mass flow sensor 22. With the aid of a filling model device 35, as explained above in connection with the model equipment 29, the air mass flow $\dot{m}$_IST inducted by the combustion chambers is ascertained. This value together with the actual values of the rotational speed n serves for the driving of a torque characteristic value field 36, which was set up with the use of the target ignition angle ZW_SOLL. Thereby, the torque value $\hat{M}$_ZWNORM, which was ascertained from the air mass flow $\dot{m}$_DK_IST, is normalised for the target ignition angle ZW_SOLL.

Fig. 5 illustrates a device 27, which is shown in dashed lines in Fig. 1, for the ignition angle limitation. An ignition angle limiter 37 is present, which keeps the ignition angle ZW_AKT within a preset range of values. A torque deviation ΔM_ZW due to ignition angle is determined with the aid of the limited ignition angle ZW_AKT and a torque deviation characteristic values field 38. Added to this in a torque summation device 39 is the torque $\hat{M}$_ZWNORM normalised for the target ignition value, whereby the 'actual' torque $\hat{M}$_IST is obtained, which can be fed to superordinate engine control devices. The marking "^" in this case indicates that the actual torque is not a measured value of the torque, but a value estimated from models. In similar manner to the field 18, the torque deviation characteristic field 38 can be two-dimensional or higher-dimensional. In addition to the described input magnitude, the value of the engine rotational speed n and/or the value of the actual air mass flow $\dot{m}$_DK_IST can be supplied.

Fig. 6 illustrates a system for fine correction of characteristic field values dependent on torque. For example, the throttle flap angle-determining device 11 in some manner contains a characteristic values field which interlinks the throttle flap angle α with the target torque M_SOLL. This field was applied for an ignition angle ZW_APP, from which, however, the actual target ignition value ZW_SOLL, which is to be normalised to, differs. If this difference in the ignition angles is disregarded, a corresponding small inaccuracy in the determination of the throttle flap angle α arises, but this is not too serious in practice, since changes in torque generally have large values which are adjusted for primarily by way of changes in air flow.

If a small error occurs in the determination of the throttle flap angle α, which causes a large change in torque, this is not too bad, since small changes are in any case cancelled by the special ignition angle measures discussed above. The equipment embodying and the method exemplifying the invention, however, operate theoretically exactly when the value for bringing the large change about, in this case the value of the throttle flap angle α, is already determined precisely. This takes place, according to Fig. 6, through a correction characteristic device 40 issuing a correction factor to a correction multiplier 41, which correction factor is so applied that a torque value is normalised for the application ignition angle. The input to the multiplier 41 can be the target torque M_SOLL, the value of which is modified before it is fed to the throttle flap angle-determining device 11, or the torque $\hat{M}$_ZWNORM, which is normalised for the target ignition angle ZW_SOLL, is issued by the torque characteristic field 36 and in turn normalised by the correction multiplier 41 for that ignition angle ZW_APP at which the torque characteristic field 36 was applied.

CLAIMS

1. A method of setting the torque of an internal combustion engine equipped with induction air regulating means, comprising the steps of predetermining a target torque value, ascertaining a target ignition angle predetermined for the actual engine operating conditions, determining the value of the actual torque normalised for the target ignition angle, determining the value of the deviation between the target torque value and normalised actual torque value, integrating the torque deviation value and correcting the target torque value by the integration value to obtain an effective torque value, controlling the regulating means by a control value dependent on the effective torque value, determining an ignition angle deviation value in dependence on the torque deviation value and so modifying the target ignition angle by the ignition angle deviation value as to provide an actual ignition angle influencing torque in a direction towards agreement of the actual torque value with the target torque value.

2. A method as claimed in claim 1, wherein the step of ascertaining the normalised actual torque value comprises measuring the inducted air mass flow, determining the air mass flow inducted into the engine combustion chambers from the measured air mass flow on the basis of an inverse filling model and determining the normalised actual torque value from a known empirically determined relationship between the determined value of the air mass flow inducted into the combustion chambers and the torque at constant target ignition angle.

3. A method as claimed in claim 1, wherein the step of ascertaining the normalised actual torque value comprises measuring the torque of the engine at the actual ignition angle and determining the torque present in the case of the target ignition angle rather than the actual ignition angle from a known empirically determined relationship between the change in torque and the ignition angle at constant filling and with the use of the actual and target ignition angles.

4. A method as claimed in any one of the preceding claims, comprising the step of determining the control value by determining an air mass flow to be inducted into the engine combustion chambers of the engine from a known empirically determined relationship between the effective torque, the engine rotational speed of the engine and that air mass flow, determining a target air mass flow to be inducted from a filling model indicating the relationship between the inducted air mass flow and the air mass flow to be inducted into the combustion chambers and determining the control value in dependence on the value for said target air mass flow.

5. A method as claimed in claim 4, wherein the step of determining the control value further comprises determining the actually inducted actual air mass flow, determining an air mass flow difference value by deducting the value of the actual air mass flow from the value of the target air mass flow, and modifying the target air mass flow value in dependence on the air mass flow difference value.

6. A method as claimed in any one of the preceding claims, comprising the step of determining the actual engine operating conditions in dependence on engine rotational speed and the actual air mass flow.

7. A method as claimed in claim 1 and substantially as hereinbefore described with reference to Fig. 1 of the accompanying drawings.

8. A method as claimed in claim 7 and modified substantially as hereinbefore described with reference to any one of Figs. 3 to 5 of the accompanying drawings.

9. Equipment for setting the torque of an internal combustion engine equipped with air induction regulating means, comprising means for predetermining a target torque, means for ascertaining a target ignition angle predetermined for the actual engine operating conditions, means for determining the value of the actual torque normalised for the target ignition angle, means for determining the value of the torque deviation between the target torque value and normalised actual torque value, means for integrating the torque deviation value and correcting the target torque value by the integration value to obtain an effective torque value, means for controlling the regulating means by a control value dependent on the effective torque value, means for determining an ignition angle deviation value in dependence on the torque deviation value and means for so modifying the target ignition angle by the ignition angle deviation value as to provide an actual ignition angle influencing torque in a direction towards agreement of the actual torque value with the target torque value.

10. Equipment substantially as hereinbefore described with reference to Fig. 1 of the accompanying drawings.

11. Equipment as claimed in claim 10 and modified substantially as hereinbefore described with reference to any one of Figs. 3 to 5 of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

Application number
GB 9320091.3

Relevant Technical Fields

(i) UK Cl (Ed.L) G3N (NGBB3) G3R (RBR)

(ii) Int Cl (Ed.5) F02D (43/00) F02P (5/04)

Search Examiner
MR D A SIMPSON

Date of completion of Search
8 NOVEMBER 1993

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) WPI

Documents considered relevant following a search in respect of Claims :-
1 TO 11

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
A	WO 90/08889	(MITSUBISHI)	
A	US 4625690	(NISSAN)	
A	US 4478185	(NIPPON SOKEN INC)	

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